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# USSR Report

## MATERIALS SCIENCE AND METALLURGY

No. 62

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20 August 1979

# USSR REPORT

# MATERIALS SCIENCE AND METALLURGY

No. 62

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USSR UDC: 539.4

# ON THE QUESTION OF THE USE OF ACOUSTIC IMPULSES FOR MECHANICAL TESTING

Kiev PROBLEMY PROCHNOSTI in Russian No 3, Mar 1979 pp 67-70

BATUNER, A. P., SHKOL'NIK, L. M., VELIKANOV, A. V., and REYKHART, V. A., Moscow

[Abstract] A study was made to establish the relationships between the acoustic impulse (AI) parameters and the characteristics of non-metallic contaminants of rail metal. A close correlation was observed between the oxide inclusions and the intensity of the AI signal and can be described by the equation

мость (рис. 4), описываемая эмпирической формулой

$$Q = (2{,}96 + 0{,}0029\dot{N}^2_{max}) \cdot 10^{-3}, \qquad (1)$$

где $Q$ — содержание окислов, %, к весу растворенного металла; $\dot{N}_{max}$ — максимальное значение интен-

where Q is the oxide content, % by weight dissolved in the metal and $N_{max}$ is the maximum value of the intensity of the AI signal, impulses/second. The use of AI signals for the non-destructive testing of the mechanical properties of steels permits the simultaneous evaluation of their strength characteristics, their plasticity and their contamination with non-metallic inclusions. Figures 5; References 3: 2 Russian, 1 Western.

USSR UDC: 621.762

# INFLUENCE OF INCLUSIONS OF BERYLLIUM OXIDE ON ANISOTROPY OF THE PHYSICO-MECHANICAL PROPERTIES OF SINTERED BERYLLIUM

Kiev PROSHKOVAYA METALLURGIYA in Russian No 4, Apr 79 pp 36-41 manuscript received 28 Mar 78

KANCHEYEV, O. D., KRAPOTIN, V. N. and POLITIKO, S. K., Moscow

[Abstract] The results are given of a study of hot-forged and hot-extruded sintered beryllium of distilled and commercial purity, with an initial powder fineness of 355 and 56 microns, for the purpose of determining the influence of the main marginal phase--beryllium oxide--on anisotropy of beryllium's physico-mechanical properties. Resistivity was measured by the potentiometric method, using a thermostat, with a margin of error not greater than $\pm$ 1 percent, and the coefficient of linear expansion by using a quartz vacuum dilatometer with 5-percent accuracy. Specimens for measurement were in the form of a hot-extruded rod and hot-forged semi-finished products. Also measured were tensile strength along and across the line of strain (in rolling, extruding, etc.), percentage elongation, and the proof stress. The structure and nature of failure in the specimens were studied with a UEMV-100K electron microscope, and the texture of semifinished products with a URS-50I diffractometer. The contribution of the oxide to anisotropy of beryllium's strength and ductility could be estimated by isolating zones of stable growth with primarily intergranular failure and zones of cascading crack evolution. In the case of hot-extruded rods, the distribution of the oxide is characterized by a "stringer" type of structure and by the extension of oxied segregations along grain boundaries in the direction of extrusion. The beryllium oxide-beryllium system is characterized by sharp delineation of boundaries between particles of both components and by the absence of contact traces and bonds; but this holds true only at relatively low temperatures, for at 900°C to 950°C a change is observed in the rate of growth of oxide particles, as a function of the content of aluminum, silicon and magnesium impurities in the beryllium. This phenomenon essentially distinguished this system from the aluminum-aluminum oxide system, in which oxide particles are exceptionally stable right up to aluminum's melting point, because oxygen practically does not dissolve in aluminum. It is not the crystallographic texture, but the existence of a grain boundary texture and the "stringer" type of oxide distribution which determine the amount of anisotropy of the tensile strength and percentage elongation of semifinished beryllium products, of rods and hot-forged stock, in particular. It is concluded that the anisotropy of resistivity and the coefficient of linear expansion in sintered beryllium are caused primarily by the crystallographic texture of the semifinished product, in this case, hot-extruded rods, and this anisotropy is not greater than 15 to 20 percent. On the other hand, the anisotropy of the tensile strength (as high as 50 percent) and percentage elongation are caused chiefly by the texture of grain boundaries and by the "stringer" type of distribution of BeO along boundaries. Figures 3; References 12: 6 Russian, 6 Western.

USSR UDC: 669.25:537.311.3

CONDUCTIVITY OF WIRE MADE OF PURE BERYLLIUM

IAN SSSR, METALLY in Russian No 3, May/Jun 77 pp 207-209

PLETENETSKIY, G. YE., KOSHKAREV, G. S., PAPIROV, I. I., TIKHINSKIY, G. F., Khar'kov

[Abstract] A study was made of the changes in resistivity of a wire made of 99.96-99.99% beryllium as a function of deformation and heat-treatment conditions, in an attempt to achieve the minimal resistivity at 77°K. The primary residual impurities were Al, Fe, Cr and Ni, though none was present in amounts greater than 0.0075 wt.%. Graphs show the influence of the degree of deformation, annealing and the temperature on resistivity. Annealing at 620°C for 30-40 hrs results in internal stress relief and segregation of impurity phases during ageing. The resulting specimens of beryllium have 5 to 6 times the conductivity of high-purity copper, silver and aluminum at liquid nitrogen temperatures. Figures 3; References 9: 6 Russian, 3 Western.

USSR UDC: 620.198.539.43.621

# IMPROVEMENT IN THE HEAT RESISTANCE OF NIOBIUM ALLOYS BY MEANS OF DIFFUSION COATINGS

L'vov FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 15 No 2, 1979 pp 65-68 manuscript received 11 Jan 78

RYBAKOV, S. V., GOYKHMAN, M. S. and SHATINSKIY, V. F., Physicomechanical Institute, Academy of Sciences Ukr SSR, L'vov

[Abstract] A study is made of the changes taking place in niobium alloys as the result of interaction with an oxidative environment and of the feasibility of improving their resistance to heat and resistance to scaling in this environment by the use of diffusion coatings applied from a molten metal solution. High-temperature oxidation of niobium alloys can result in a change in the mechanical characteristics of these alloys. If the rate of diffusion of oxygen in the alloy is sufficiently high, internal oxidation takes place and the alloy hardens and loses ductility. If the rate of diffusion of oxygen in the alloy is less than the rate of diffusion of alloying elements, then hardening of the alloy takes place because of the depletion of the solid solution by alloying elements in selective oxidation. In the latter instance ductility can even increase, approaching that of unalloyed niobium. Protective diffusion coatings make it possible to reduce the rate of high-temperature oxidation and avert solid-solution hardening of a niobium alloy, by preventing direct contact between the material and the environment. The method of diffusion impregnation from melts of low-melting metals is used. Single-component coatings of Zr, Re, Be, Ni and Y were applied, as well as two-layer coatings of Zr-Pd, Re-Pd, Re-Be and Pd-Be. It has shown that single-component coatings of Zr and Re and two-layer coatings of Zr-Pd and Re-Pd make it possible to protect alloy 5VTTs from oxidation over a period of 50 hrs in a 1.3 and $7 \cdot 10^{-4}$ Pa vacuum at 1050°C. Coatings of Re and Re-Pd prevent the alloy from oxidation and harden it considerably; coatings of Zr and Zr-Pd make it possible to hold the ductility at the same level as in samples without coatings. In terms heat resistance, the best protection for alloy 5VMTs in air at 900°C is rendered by single-layer coatings of Be, Ni and Y and two-layer coatings of Pd-Be and Re-Be. It is concluded that for the purpose of improving heat resistance of niobium alloys in air at temperatures up to 900°C it is best to use a two-layer coating of Pd-Be; in a 1.3 Pa vacuum the best figures for resistance to heat and resistance to scaling are given by coatings of Re, Zr and Re-Pd. Coatings of Zr and Zr-Pd are preferred for the purpose of improving these indicators in a $7 \cdot 10^{-4}$ Pa vacuum. Coatings containing Re increase the resistance of a niobium alloy but reduce its ductility considerably. Coatings containing Zr make it possible to keep the ductility at the level of an uncoated material. Figures 2; References 6: all Russian.

USSR UDC: 666.283

INFLUENCE OF GLASS-ENAMEL COATINGS ON THE MECHANICAL PROPERTIES OF THE SURFACE LAYERS OF 08 SP STEELS

Kiev PROBLEMY PROCHNOSTI in Russian No 3, Mar 1979 pp 57-59 manuscript received 12 Nov 77

MIZONOV, V. M., KIZHNER, M. M., LYASHENKO, B. A., and SHKLYAR, V. I., Poltava, Kiev

[Abstract] A study was made of the chemical composition, micro-hardness and microstress on ceramic-coated steels. Diffusional redistribution of elements occurred with the formation on the metal surfaces of diffusion zones, depleted in maganese and enriched in silicon, boron, and titanium. The diffusional processes at the metal-ceramic boundary were accompanied by changes in the mechanical properties in the surface layer of the steel which may profoundly influence its strength properties. The mechanical properties of the surface layers of the steels are related to the number of times the ceramic-coated metal was fired. Figures 3; References 10: all Russian.

USSR UDC: 621.762

# MODERN CONCEPTS REGARDING THE MECHANISM OF FRICTION AND WEAR AND KEY TRENDS IN THE DEVELOPMENT OF COMPOSITE MATERIALS FOR FRICTION EQUIPMENT

Kiev POROSHKOVAYA METALLURGIYA in Russian No 4, Apr 79 pp 53-66 manuscript received 18 Dec 78

FEDORCHENKO, I. M., Institute of Problems of Material Science, Academy of Sciences Ukr SSR

[Abstract] A survey is given of progress in the study of processess accompanying friction and wear and contributing to them, and of composite materials developed at the Institute of Problems of Material Science which are intended for use in friction equipment. Briefly discussed among the most studied processes accompanying the friction process are oxidation processes, diffusive redistribution of elements in the surface layer, selective transfer of elements during friction, phase and structural transformations, adsorption-related diminution of the strength of the surface layer, the role of structure in distribution of stresses and in the resistance of a material to wear, and amorphization of the structure of the surface layer. Judged as the most important trend in study of the mechanism of friction and wear is the investigation of amorphization processes and the physicomechnaical and frictional properties of amorphous layers, and of the conditions for converting these layers into the crystalline state. Powder metallurgy technology makes it possible to control the composition and structure of composite sintered materials and thus direct friction processes as required. Of the materials developed, briefly surveyed are sulfided graphite, ferrofluoride materials, filled-matrix materials, bronze-armored fluoroplastic materials with a stainless steel support, metal-graphite materials, antifriction stainless steels, iron-based "SMK" materials (based on 46 to 54 percent iron and nine to 25 percent copper, with additions of Mc, BN, $B_4C$ SiC and $MoS_2$), and copper-based friction materials. The principles on which modern antifriction materials are based include the intelligent selection of a material "design" which ensures the proper combination of hard, strong structural elements to receive the stress, and a plastic strainable matrix to support these elements and distribute the stress evenly over the mass of the bearing. This goal has been met by the creation of materials of the filled matrix or armored type, by combining a shell of hard-compound particles with a plastic alloy as a matrix, utilizing the sintering method or the melt impregnation method, or by armoring a low-strength antifriction material with a stronger shell. The key trends in the area of developing friction materials for performance under severe conditions include improving their flame and heat resistance, resistance to scaling, and fatigue strength, substituting with more stable additions those which are unstable at high temperatures, and selecting as the materials's base alloys which do not undergo phase transformations at temperatures occurring in the friction process. Figures 11; References 10: 8 Russian, 2 Western.

USSR UDC: 621.762.52:669.018.4:661.882.621:536.21

# THERMOPHYSICAL PROPERTIES OF HOT-FORGED TiC-C AND ZrC-C COMPOSITE MATERIALS AT HIGH TEMPERATURES

Kiev POROSHKOVAYA METALLURGIYA in Russian No 4, Apr 79 pp 67-71 manuscript received 27 Jun 78

GORINSKIY, S. G., SHABALIN, I. L., KORSHUNOV, I. G., BEKETOV, A. R. and KOKORIN, A. F., Ural Polytechnical Institute imeni S. M. Kirov

[Abstract] A study is made of the properties of titanium carbide--carbon and zirconium carbide--carbon composite materials with a carbon phase content of from 10 to 40 percent by volume, obtained by compression molding in graphite molds, utilizing a high-temperature vacuum unit, at 3000°K at a pressure of 12 MPa in an argon environment. Data are presented on the chemical composition and physico-mechanical and structural characteristics of these materials. The specific heat and thermal conductivity of these composites are determined by placing a sample in the chamber of a special unit at a pressure of $10^{-5}$ to $10^{-6}$ mm Hg and heating the sample with a flow of electrons from a tungsten cathode at a voltage of about 2kV, and then measuring the temperature of the sample with a VR5/20 thermocouple. The dependence of temperature on specific heat is governed by the relationship $c = a + bT$, where a and b are constants whose values are a function of the composition of the composite. A determination is made of the thermal conductivity coefficients of these composites, based on experimental data on the specific heat, thermal conductivity and density of carbide-carbon materials; these coefficients are shown to depend considerably on the direction of the hot-forging axis. Metallographic studies demonstrate that these composites are structurally a continuous carbide matrix with a carbon inclusions distributed in it. The graphite microcrystallites have a preferred orientation at right angles of (00$\ell$) planes along the hot-forging axis. With a low feee-carbon content, the thermal conductivity of these composites is determined mainly by the thermal conductivity of the individual carbide. With an increase in the unit content of the carbon phase the degree of anisotropy of the materials's thermal conductivity increases. Along the line perpendicular to the axis of compression, the thermal conductivity coefficient increases with an increase in graphite content, the graphite evidencing a considerable phonon component of thermal conductivity in directions along (00$\ell$) planes. Phonon-phonon interaction is the key process restricting thermal conductivity in the high-temperature region; because of this interaction, the thermal conductivity of these composites is reduced with a rise in temperature. Along the line parallel to the axis of compression, the thermal conductivity of these composites is reduced with an increase in the unit carbon content, because of the moderate value of the graphite's thermal conductivity coefficient along the line perpendicular to (00$\ell$) planes. The notions presented here form the basis for varying the thermophysical characteristics of carbide-carbon composite materials by varying the ratio of varbide and carbon phases in these composites. Figures 3; References 16: all Russian.

USSR UDC: 620.194

# THERMODYNAMIC ANALYSIS OF THE CHEMISM OF SALT CORROSION OF TITANIUM ALLOYS

L'vov FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 15 No 2, 1979 pp 45-49 manuscript received 9 Nov 74

TRAVKIN, V. V., PSHIRKOV, V. F. and KOLACHEV, B. A., Moscow Aviation Technology Institute

[Abstract] A thermodynamic analysis was made, along with a study of about 200 possible chemical reactions of metals, salts and oxides in the solid state with water in the gaseous state and with the gases $O_2$, $Cl_2$ and HCl, for the purpose of making a systematic analysis of reactions possibly responsible for the stress-corrosion cracking of titanium alloys. From consideration of dependences of the thermodynamic potential on temperature in oxidation reactions, it is concluded that at temperatures up to 600°C on the surface of titanium alloys oxide salts can form which have a complex chemical composition, representing oxides of titanium and oxides of alloy components. Previous experimental data have testified to the presence of oxide films at points of corrosive failure. Two probable thermodynamic systems are suggested for the chemism of the salt corrosion of titanium alloys. They are (I): 1. Ti + chloride + + $H_2O$ + $O_2$ → $TiCl_n$ + ...; 2. $TiCl_n$ + $H_2O$ + $O_2$ → $Ti_mO_n$ + $Cl_2$ + HCl +...; 3. $Me(Me_m)_n$) + $Cl_2$ → $MeCl_x$ +...; 4. $Me(Me_mO_n)$ + HCl → chloride + $H_2$; and (II) 1. Ti + chloride + $O_2$ → $Ti_mO_n$ + $TiCl_n$ + $Cl_2$; etc., in keeping with system (I). With salt, moisture and atmospheric oxygen present on the surface of titanium alloys, complex chemical reactions take place, with the formation of chlorides of titanium and of alloying components of the alloy, and free chlorine or hydrogen. In the pyrohydrolysis or oxidation of chlorides, free chlorine or hydrogen chloride are separated, and these interact with the alloy to form salts, and the hydrogen can be absorbed by the metal and cause embrittlement. A very slight amount of chloride on the surface can support the corrosion process intensely and for a long time. Sodium chloride plays the role of a catalyst and accelerates the chlorination process. Chlorine, hydrogen chloride and hydrogen are the most hazardous agents for titanium alloys under conditions of salt corrosion. The thermodynamic systems suggested have been confirmed experimentally by a determination of products of salt corrosion, using a URS50-IM diffractometer. The application of tensile stresses greater than the threshold stresses for salt corrosion facilitates the occurrence of quasi-autocatalytic chemical reactions and the dissolution of hydrogen in the metal, causing cracking of the oxide film and the formation of fresh surfaces. Microcracks and pits result from selective interaction on the most active surfaces, and these act as local stress concentrators which promote the growth of cracks on the surface of the alloy. Figures 2; References 6: 4 Russian, 2 Western.

USSR UDC: 669.14.018.44:620.193.462.21

HIGH-TEMPERATURE SULFIDE CORROSION OF NICKEL ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 79 pp 42-43

BELIKOV, S. B., GAYDUK, V. V. (deceased), KULYGIN, G. V. and NATAPOV, B. S. (deceased)

[Abstract] The effect of certain alloying elements on the resistance to high-temperature sulfide corrosion of heat-resistany nickel alloys was investigated. Alloys of the Ni-Cr-W-Co (19-30% Cr) system with additions of 2-6% Al, 2-3% Ti and 2-4% Mo were placed in a test chamber and heated by a fuel which had 0.9-1.1% sulfur added and subjected to the combustion products for 40 hours with individual steps of 10 hours. The minimum corrosion rate was shown by the alloys with the highest Cr content while those with Mo had highest corrosion rate. Titanium also helped reduce sulfide corrosion in these alloys. The good corrosion resistance caused by Cr and Ti was due to the formation of dense protective films of $Cr_2O_3$ and $TiO_2$.

USSR UDC: 621.791.052:669.265'74:620.192

TENDENCY OF NITROGEN-CONTAINING, CHROMIUM-MANGANESE AUSTENITIC STEEL TO INTERCRYSTALLINE AND PITTING CORROSION

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 79 pp 27-29

SHLYAFIRNER, A. M. and KRAVCHENKO, V. G., Candidates of Technical Sciences, and DIVIDKIN, B. F. and YAKUBOVA, G. P., Engineers, Central Scientific Research Institute of Structural Steel Design

[Abstract] Research was conducted for the purpose of producing mathematical relationships between the magnitude of seam metal grain and welding conditions using a granulated metallic welding rod. Samples were cut from 06KhN28MDt steel (30 mm thick) and welded in an X-shape using welding rod Sv-01Kh23N28M3D3T. The primary structure of the weld consisted of coarse equiaxial crystalline grains on the fused grains of the base metal. The crystalline grains had fine equiaxial grains adjoining them from which columnar crystallites grew in a direction opposite that of the heat dissipation. The dimensions of the columnar grains were independent of the base metal. Relationships were obtained which allowed determination of grain size both in the heat-affected zone and in the seam metal. The size of equiaxial grains on the fusion line, in contrast to the width of the columnar crystallites, depended very little on welding mode. Width of the columnar crystallites exceeded the grain sizes on the fusion line by several times, as determined by the distance from the base metal. Figures 3; References 6: 5 Russian, 1 Western.

USSR UDC: 669.14.018.44:620.186.4

EFFECT OF HEAT TREATMENT ON THE TECHNOLOGICAL DUCTILITY OF NICKEL ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 79 pp 30-33

BURNAKOV, K. K., KHASIN, G. A., DANILOV, V. F., OSHCHEPKOV, B. V. and LISTKOVA, A. I., Kurgan Machine Building Institute and the Zlatoust Metallurgical Plant

[Abstract] The causes of low technological ductility of KhN75MBTYu (EI602) and KhN78T (EI435) alloys and the effect of heat treatment on them were studied. Investigation was conducted on heats having scab defects in them after forging. Impact test samples were heated to 700-1200°C for 1-20 hours with subsequent cooling in air and water. Tests were conducted at 20, 900, 1100 and 1200°C. It was noted that there were two types of inclusions in the structure of the intercrystalline fracture of both alloys. These inclusions were dendritically situated and consisted of alpha-$Al_2O_3$, $FeO(Cr_2O_3 \cdot Al_2O_3)$ and coatse plate inclusions of $SiO_2$, FeO and $(CrFe)_2O_3$ located in individual colonies. Heat treatment did not increase their impact strength and did not improve ductility. Heating above 1000°C leads to partial dissolution and coalescence of film inclusions, which promotes increased impact strength of the alloys at room temperature. Figures 5; References 5: all Russian.

USSR UDC: 621.791.052.01:620.192.4:669.14.018.44:621.78

EFFECT OF HEAT TREATMENT MODES ON HEAT RESISTANT KhN73MBTYu (EI698) ALLOY

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 79 pp 23-27

MOROCHKO, V. P., Engineer, YAKUSHIN, B. F. and SOROKIN, L. I., Candidates of Technical Sciences, and SMIYAN, I. A., Engineer

[Abstract] EI698 alloy was used in a study of the nature of plastic deformation and relaxation rate from heat treatment before and after welding. Ti and Al content of the alloy was 4.5%. A localization of plastic deformation was found in the seam and heat-affected zone of weld joints during relaxation of stresses in the heat treating process. Cracks in the joint form as the result of a low resistance of strained seam and heat-affected zone sections owing to loss of ductility. By annealing at 1100°C, step cooling before welding, and step tempering after welding it is possible to substantially remove stresses and strengthen the seam zone and prevent cracking in this alloy. The post-weld heat treatment consists of cooling to 830°C and soaking for three hours, cooling at the rate of 2° min to 775°C and soaking for 16 hours, followed by air cooling. Figures 8; References 8: 3 Russian, 5 Western.

USSR UDC: 669.721'974'71

PHASE EQUILIBRIA IN Mg-Y-Al ALLOYS

IAN SSSR, METALLY in Russian No 3, May/Jun 77 pp 223-227 manuscript received 10 Apr 78

DRITS, M. YE., PADEZHNOVA, YE. M., DOBATKINA, T. V., Moscow

[Abstract] A study was made to determine the nature and temperature of nonvariant equilibria in magnesium-rich alloys in the system Mg-Y-Al and to determine the mutual solubility of yttrium and aluminum in solid magnesium. The method of differential thermal, microstructural, microscopic x-ray diffraction analysis and determination of the mechanical properties of the alloys were used. Photomicrographs of the microstructure and isothermal cross sections through the state diagram of the alloys at various temperatures are presented. Two nonvariant peritectic equilibria are found in the magnesium corner of the system, at 631 and 438°C. Small quantities of aluminum (up to 0.5%) are found to have a positive influence on the strength properties of Mg-Y alloys. Figures 3; References 5: 3 Russian, 2 Western.

USSR UDC: 621.793:658.3

# METHOD OF MONITORING DETONATION SPRAY COATING

Kiev POROSHKOVAYA METALLURGIYA in Russian No 4, Apr 79 pp 72-73 manuscript received 5 Apr 78

KLIMENKO, V. S., SKADIN, V. G. and BORISOVA, A. L., Institute of Problems of Material Science, Academy of Sciences Ukr SSR, "Leninskaya Kuznitsa" Central Design Bureau

[Abstract] It is demonstrated that it is possible to monitor the operation of the powder dispenser, i.e., to estimate the powder cloud's size and the amount of powder contained in it, by registering changes in the power of the light emission from the pulsed high-temperature flow which originates in detonation spray coating, in spraying powders onto a substrate. This possibility is proven experimentally with a setup consisting of a series-connected photoelectric transducer, a two-stage amplifier, a recorder, and a stabilized power supply. The transducer, an FD-3A photodiode, is put into a special container and placed near the open end of the detonation unit's barrel. The output of the connecting line is connected to the final stage of the amplifier, which is located outside of the unit along with the recorder, in the form of an S1-48B oscillograph with a photo attachment, and the stabilized power supply. The amplifier's other stage is mounted in the container with the transducer, to eliminate the influence of noise from the detonation unit. The registering of variations over time in thepower of the light emission from the pulsed high-temperature flow demonstrates that in the explosion of a gas mixture not containing powders of the material to be sprayed the power of the light emission of the detonation products, as they flow from the barrel. varies nonlinearly. When powder particles are contained in the sprayed material, the power of the light emission increases suddenly the moment the powder cloud is emitted from the barrel. The increase in the power of the light emission at the point in the flow where the powder cloud is found is proportional to the amount of powder contained in it. Oscillograms illustrate the influence of the position of the powder cloud in the detonation products, in relation to the front of the detonation wave. The position of the powder cloud is regulated by varying the lead time for pulsed feeding of the powder to the barrel in relation to the moment of initiating the burst. Figures 1; References 1 Russian.

USSR UDC: 669.14.018.44:669.85/86:620.186.4

# EFFECT OF RARE EARTH ELEMENTS ON THE COMPOSITION OF NONMETALLIC INCLUSIONS AND HEAT RESISTANCE OF AN AUSTENITIC STEEL

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian
No 5, May 79 pp 39-42

FARAFONOV, V. K., SHTEYNBERG, M. M., KUKHTIN, M. V., CHEREMYKY, V. P. and VOYNOV, V. V., Scientific Research, Design and Technological Institute of Heavy Machine Building of Uralmashzavod and the Chelyabinsk Polytechnical Institute

[Abstract] The effect of rare earth metals (lanthanum, enodymium, praseodymium and cerium) on the composition of nonmetallic inclusions and the heat resistance was studied for an austenitic steel containing (in %): 0.05-0.07 C, 14.5-15.5 Cr, 19.5-20.5 Ni, 0.40-0.60 Si, 0.009-0.014 S and 0.012.0.014 P. The REM in metallic form were added to the ladle after the initial heat had been poured, diffusion annealed, forged into rods and remelted. Upon releasing up to 0.1% rare earth metal into the steel the total amount of nonmetallic inclusions changes little except for the usual sulfide and oxide inclusions being replaced by sulfide and oxide inclusions of the rare-earth elements. A further increase in the REM content leads to a significant growth in the amount of new nonmetallic inclusions containing the REM, phosphorus and nonferrous metal impurities. The concentration of sulfur in these inclusions is much less than in the REM oxysulfides and in some inclusions there is almost no sulfur. REM increase the ductility of the steel in long-time tests. With increased REM content the time to fialure is initially intense, grows, achieves a maximum at 0.1% REM, and then decreases to initial values. The creep rate changes little initially but then grows sharply in conjunction with the increased quantity of nonmetallic inclusions in the steel. Figures 4; References 4: 3 Russian, 1 Western.

USSR UDC: 669.14.018.44:620.193.4

EFFECT OF AIR FLOW ON THE SURFACE STATE OF HEAT-RESISTANT ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 79 pp 43-45

VEKSLER, YU. G., GUZANOV, B. N., and SOROKIN, V. G.

[Abstract] The causes of premature lowering of structural stability in the surface layers of the blades of gas-turbine engines was studied using industrial alloys EI437B and EI929. Electron microscope studies of the surface layers of EI929, which had been soaked in air at 950°, showed that gamma'-phase particles had a cubic form which was uniformly distributed in the main solid solution and comparatively uniform in size. After testing in a rapid air flow the surface layer structure showed that there was significant dissolution and coalescence of the gamma'-phase. Portions of the strengthening phase were connected and formed large coarse precipitates. Tests with EI437B showed that the depth of the weakened oxidized layer is 60-80 microns and after this layer is removed the alloy assumes its original strength properties. Thus, the basic reasons for loss of structural stability in this alloy are decomposition of the solid solution and coalescence and dissolution of the strong gamma'-phase. Figures 3; References 3: all Russian.

USSR UDC: 621.921.37

EFFECT OF PHASE COMPOSITION ON THE STRENGTH OF POLYCRYSTALLINE SUPERHARD MATERIALS BASED ON BORON NITRIDE

Kiev SINTETICHESKIYE ALMAZY in Russian No 5, 1978 pp 3-8

SOZIN, YU. I., BELYANKINA, A. V., PRIKHNA, A. I. and GERASIMENKO, V. K., Institute of Superhard Materials, Academy of Sciences UkrSSR

[Abstract] This is a continuation of an earlier investigation of the qualitative phase analysis of polycrystalline superhard materials based on boron nitride (Prikhna. A. I., et al. SINTETICHESKIYE ALMAZY, 1977, No 3, pp 19-23), with the difference that now the procedure and findings of a quantitative study of their phase composition are presented. A formula for determining phase concentrations is presented. The constants in that formula are determined with the aid of four standard mixtures including hexagonal graphite-like boron nitride ($BN_g$), wurtzite-like boron nitride ($BN_w$), and sphalerite-like boron nitride ($BN_{sph}$), on using a diffractometer with nonfiltered Cu radiation, on the basis of the ratio between peak intensities. Given the same content of $BN_g$ the strength of the specimens containing one of the dense modifications of boron nitride is lower than that of specimens containing both modifications in substantial proportions. It can be concluded that the preparation of optimally strong polycrystals of superhard materials through the application of high pressures and temperatures to $BN_w$ requires a roughly identical content of dense phases in the final product, which is achieved by the proper selection of temperatures and by precluding the presence of the graphite-like modification. An increase in $BN_g$ content reduces the strength of the polycrystals, while the combined presence of the superhard phase $BN_{sph}$ and the more plastic phase $BN_w$ optimizes their mechanical properties. Figures 4; References 6: all Russian.

USSR UDC: 539.893

DESIGN ANALYSIS OF HIGH PRESSURE CHAMBERS

Kiev SINTETICHESKIYE ALMAZY in Russian No 5, 1978 pp 8-15

GERASIMOVICH, A. V., Institute of Superhard Materials, Academy of Sciences UkrSSR

[Abstract] There now exist numerous design of which pressure chambers capable of generating and maintaining pressures of 40-80 kbar at high temperatures, but their suitability for industrial synthesis of diamonds differs. Chambers containing two dies with variously shaped recesses

in abutting faces are inferior in operating life and volume to chambers of other types, especially the belt and cubic types which are used to synthesize superhard materials. The following chamber characteristics are compared: ratio of the volume of the high-pressure cavity to its surface; cavity volume per unit press force for a specified chamber pressure; ratio of press force to force exerted on side walls, and the stressed state of the components bounding the high-pressure cavity. In addition, allowance must be made for the geometric shape of the high-pressure cavity. Analysis of all these characteristics indicates that the belt chamber can be used at comparatively low pressures. The chamber with recesses can be used at higher pressures. The cubic chamber can be used at the highest pressures. Normally the resistance of chambers with recesses decreases sharply with increase in their working volume, owing to the thiness of the projecting edge. In this connection, the Institute of Superhard Materials has developed a chamber with recesses in the shape of a cone couple to a sphere, designed for stress of 1000 tons (working volume 9 $cm^2$). The relative thickness of the projecting edge for that chamber could be increased by a factor of 1.35 times compared with the chamber having a working volume of 5.2 $cm^3$. The service life of the new chamber when used for diamond synthesis then increased by a factor of 2.6 times. Figures 3; References 11: 8 Russian, 1 Polish, 2 Western.

USSR UDC: 666.233-987

PROLONGATION OF SERVICE LIFE OF HIGH PRESSURE CHAMBERS FOR DIAMOND SYNTHESIS

Kiev SINTETICHESKIYE ALMAZY in Russian No 5, 1978 pp 16-18

PIVOVAROV, M. S., BARABAN, V. P. and ZHEREBTSOV, YU. V., Poltava Synthetic Diamonds and Diamond Tools Plant; LOSHAK, M. G. and ALEKSANDROVA, L. I., Institute of Superhard Materials, Academy of Sciences UkrSSR

[Abstract] The performance of equipment for the synthesis of superhard materials largely depends on the durability of high-pressure chambers, whose most stressed components are made of hard alloys of the tungsten group. The principal cause of the breakdowns of these chambers is the fatigue fracture of their hard-allow components. Hence the service life of the chamber can best be prolonged by enhancing the strength of these components. Accordingly, the Institute of Superhard Materials has developed a technique for hardening hard alloys by means of a heat treatment that resulted in increasing their bending strength 8-15%; impact strength, by 20-30%; and durability under impact and harmonic loads, 2-6 times (see Loshak and Aleksandrova, "Uprochneniye Tverdykh Splavov" [Hardening of Hard Alloys], Kiev, Naukova Dumka, 1977, p. 147). This technique has been introduced and tested at the Poltava Synthetic Diamonds and Diamond Tools Plant since 1975 on chamber components of VK6 and VK15 hard alloy. In

most cases such heat treatment has been observed to result in a 13-70% increase in operating life. But in some of the batches the increase in resistance following heat treatment was insignificant or nil. It is established that in such cases the ineffectiveness of heat treatment is due to the presence of free carbon (graphite) in the sintered hard alloys ($\leq$ 0.6 vol%) as well as to increased porosity ($>$ 0.1 vol%). Heat treatment of hard alloys results in additional dissolution of W and C in Co and thus affects deformation resistance in a manner which depends on the alloy's content of binding phase. Reducing the number of structural defects represented by graphite and porosity enhances the service life of hard-alloy components. Figures 1; References 3: all Russian.

USSR UDC: 548.73

A STUDY OF MONOCRYSTALS OF SPHALERITE-LIKE BORON NITRIDE

Kiev SINTETICHESKIYE ALMAZY in Russian No 4, 1978 pp 13-17

BELYANKINA, A. V., SOZIN, YU. I., PETRUSHA, I. A., Institute of Superhard Materials, Academy of Sciences UkrSSR

[Abstract] The morphology and substructure of moncrystals of the sphalerite-like modification of boron nitride ($BN_{sph}$) synthesized within 2-4 min under high pressures (30-40 kbar) and temperatures (1100-1500°C) from hexagonal boron nitride in the presence of a solvent-metal and boron- and nitrogen-containing additives are considered. Crystals of several types, particularly those with near-octahedral faceting and smooth faces and transparent crystals in the shape of lamellae of pseudohexagonal form were investigated. The spots on Laue diffraction patterns of the crystals with near-octahedral faceting are distinct and hence the structure of these crystals is close to ideal, since they do not contain differently oriented subgrains. Analysis of the Laue diffraction patterns of crystals in the shape of lamellae of hexagonal form shows that they represent twins following the spinel pattern. On the whole, it is concluded that $BN_{sph}$ crystals synthesized from the graphite-like modification of boron nitride usually do not show broadening of reflections on their x-ray patterns and hence their structure is close to that of perfect crystals. When grown from a seed charge, crystals of the sphalerite-like modification of born nitride are mosaic, with the mosaic blocks measuring 10-20 m in size, and their dislocation density is of the order of $10^8$ $cm^{-2}$. Figures 3; References 8: all Russian.

USSR UDC: 621.762.5

# INTERACTION BETWEEN BORON NITRIDE AND STEELS AND TITANIUM

Kiev SINTETICHESKIYE ALMAZY in Russian No 4, 1978 pp 17-22

VISHNEVSKIY, A. S., DELEVI, V. G., MUKOVOZ, YU. A., OSITINSKAYA, T. D., and CHAPALYUK, V. P., Institute of Superhard Materials, Academy of Sciences UkrSSR

[Abstract] Tools made of cubic boron nitride display an anomalously high wear when used to machine certain titanium alloys and stainless steels, apparently owing to the specificity of their interaction with certain alloy elements. Hence, the nature of that interaction was investigated on powders of the cubic ($\beta$-BN), hexagonal ($\alpha$-BN) and wurtzite-like ($\nu$-BN) modifications of boron nitride (particle size 4-10 $\mu$m in all cases) heated in a crucible in contact with specimens of the steels 45, 4Kh13, 1Kh18N10T, and the titanium alloy VT3-1, kept at up to 1400, 1500, and 1600°K for 5 hrs. The metal specimens in contact with BN were subsequently investigated by method of metallography, x-ray structural analysis, x-ray microanalysis. The VT3-1 titanium alloy was found to then contain a layer of the $\alpha$-phase whose thickness increases with increased temperature. The transition from the two-phase ($\alpha$ and $\beta$) to a single-phase ($\alpha$) structure of the surface of that layer is due to its saturation by nitrogen released at 1523°K, which reacts with chromium or other elements of the system, probably with the formation of nitrides. The interaction of BN with steels is more complex. In the Cr-treated steels Cr interacts with BN at $<$ 1423°K, whereas at higher temperatures both Fe and Cr interact with BN. Of all the BN modifications, the cubic modification interacts most actively with metals upon heating. The temperature at which BN begins to react with the components of the alloy being machined characterizes the strength of the cubin-BN cutting tool. In cases in which the temperature of reaction onset is higher than the contact temperature in the cutting zone, the cutting tool and the metal (alloy) being machined are chemically inert relative to one another. Under such conditions, e.g., in the machining of iron and of carbon steels, the strength of cubic-BN cutting tools is high. Interaction between Ti and Cr, on the one hand, and BN on the other, is possible at temperatures 200-300°K lower than those required for the reaction of BN with Fe. When Ti and Cr are present in an alloy, the cutting-zone temperature triggers a reaction between them and BN, and in such cases and strength of the cutting tool diminishes sharply. Figures 3; References 4: 3 Russian, 1 Western (in Russian translation).

USSR UDC: 621.762.5

# A STUDY OF THE INTERACTION BETWEEN CUBIC BORN NITRIDE AND THE TRANSITION METALS AND THEIR CARBIDES

Kiev SINTETICHESKIYE ALMAZY in Russian No 4, 1978 pp 22-25

BONDARENKO, V. P., KHALEPA, A. P. and CHEREPENINA, YE. S., Institute of Superhard Materials, Academy of Sciences UkrSSR

[Abstract] This is a continuation of an earlier investigation of the thermodynamics of the interaction between boron nitride and the transition metals under standard conditions (Bondarenko and Khalepa. SINTETICHESKIYE ALMAZY, No 2, 1977, pp 13-18), with the difference that now the solid-phase interaction in vacuo between cubic boron nitride on the one hand, and Ti, Cr, Mo, and the carbides of titanium (TiC) and chromium ($Cr_3C_2$) is investigated. To this end, mixtures of powders of these metals with powder of cubic BN are annealed in a SShVL type furnace in a vacuum ($2.7 \cdot 10^{-4}$ mm Hg) at 1973-1773°K for 1 hr and then cooled together with the furnace at the rate of 1°C/min and subjected to x-ray phase analysis. The ratio between components was computed from the reactions of the metals and carbides with hexagonal BN, which has the highest probability of flow in vacuo from the standpoint of thermodynamics. Formulas for the temperature dependences of the isobaric-isothermal potentials of the corresponding in vacuo reactions between hexagonal BN and the specified transition metals and their carbides are presented. In these conditions, within the 1073-1673°K range cubic BN does not interact with the carbides of titanium and chromium, but it begins to interact with Ti at 1673°K with Cr, at 1473°K; and with Mo, at 1373°K. The solid-phase interaction between cubic BN and Ti in vacuo during isothermal exposure for 1 hr results in the formation of the titanium borides $TiB_2$ and TiB and the titanium nitride TiN. In the same conditions the interaction between cubic BN and Cr and Mo results in the formation of the chromium boride $Cr_2B$ and the molybdenum boride $Mo_2B$, respectively. The reactions between the metals and hexagonal BN are the same as in the interaction of the metals with cubic BN, since the findings of theory are in agreement with experiment. X-ray phase analysis revealed no interaction within the system metal carbide-cubic BN, although thermodynamic reactions in vacuo within the 0-1500°K range are possible in theory. Figures 1; References 5: all Russian.

USSR UDC: 621.941.025:661.65

# PERFORMANCE OF CUTTING TOOLS MADE OF BORON NITRIDE-BASE POLYCRYSTALS IN THE MACHINING OF HARDENED STEEL

Kiev SINTETICHESKIYE ALMAZY in Russian No 4, 1978 pp 48-50

ZUBAR', V. P., KRYUKOV, V. K. and TIMCHUK, A. G., Khar'kov Polytechnic Institute: KARYUK, G. G., Institute of Problems of Material Science, Academy of Sciences UkrSSR

[Abstract] The extent of the plastic deformation of the cut layers of metal during the machining of hardened ShKh15 steel by means of boron nitride-base polycrystal cutting tools was determined from measurements of the skrinkage of chips. In this connection, the effect of cutting rate on chip shrinkage during the machining of ShKh15 steel by cutting tools made of elbor-R, hexanite-R and (for comparison) T15K6 hard alloy was determined. In all cases the increase in cutting speeds resulted in a reduction of chip shrinkage. This shows that the mechanism of the cutting of hardened steels by cutting tools made of the aboce materials is the same. However, chip shrinkage when using elbor-R cutting tools is somewhat greater than when tools of hexanite-R are used, apparently because the heat conductivity of elbor-R is somewhat higher than that of hexanite-R, so that higher temperatures of contacting surfaces are reached at lower cutting speeds in the case of hexanite-R. Correspondingly also the coefficient of friction between the contacting surfaces of the cutting tool made of hexanite-R and the hardened-steel blank is lower, 0.21-0.24 compared with 0.21-0.24 for elbor-R. These findings can be used to correctly estimate the performance and optimal operating conditions of cutting tools based on boron nitride. The optimal performance of these cutting tools is achieved within a comparatively narrow range of cutting speeds: 60-80 m/min for elbor-R and 30-35 m/min for hexanite-R compared with 20-25 m/min for T15K6 hard alloy. At these speeds the metal in the contact zone is in the plastic state, and they correspond to the chip shrinkage k = 1.25. If these speeds are increased any further the cutting tools experience thermal wear owing to heat-induced structural transformations of hexanite and elbor. It is further established that the surface roughness of hardened ShKh15 steel blanks machined with hexanite cutting tools is lower than that of the blanks machined with elbor cutting tools, because of the coefficient of friction between hexanite-R and that steel is lower than for elbor-R, and, secondly, because the strength of the cutting edge of tools made of hexanite-R is somewhat greater, and also because the heat conductivity of the polycrystals of hexanite-R is lower than that of elbor-R, and therefore the temperature needed to achieve the desired geometry of the surface layer is reached at lower cutting speeds. Thus, on the basis of these findings, the optimal cutting speeds for different BN-base polycrystal cutting tools can be selected. Figures 3.

USSR UDC: 669.295:548.735.6

# INFLUENCE OF HIGH TEMPERATURE THERMOMECHANICAL TREATMENT AND THERMAL HARDENING TREATMENT ON THE TEXTURE AND PROPERTIES OF STAMPINGS OF ($\alpha+\beta$) TITANIUM ALLOY VT3-1

IAN SSSR, METALLY in Russian No 3, May/Jun 77 pp 147-155, manuscript received 18 Jul 78

BABAREKO, A. A., BETSOFEN, S. YA., IL'IN, A. A., BUNIN, L. A., SUKHORUKOVA, L. I., Moscow

[Abstract] Hemispheres 338 mm in diameter with wall thickness of 5 and 25 mm were made by closed-impression die forging 960, 1050 and 1150°C and hardened by quenching in water. Specimens were then cut from the middle portion of the hemispheres: some of the specimens were rehardened by quenching from 820, 850, 880, 900 and 1050°C and aged at temperatures from 400 to 700°C for 5 hours, then annealed at 820 and 850°C and cooled with the furnace. At each stage in the processing, x-ray studies were performed of the texture and phase composition of the specimens. It was found that forging at 1050-1150°C with quenching in water directly from the die produced a texture which was favorable for use at high internal pressures. All of the high temperature thermomechanical treatment sequences studied successfully prevented the formation of harmful single-component prismatic texture, which is produced when specimens are cooled with the die. It was found that the development of the texture of the $\alpha$ phase is controlled basically by the distribution of external and residual internal stresses or, if there are no stresses, by the hereditary dislocation structure of the $\beta$ phase. Figures 5; References 2: 1 Russian, 1 Western.

## BRIEFS

METHOD OF DYEING TITANIUM--A method of dyeing titanium through anodization in a special electrolyte has been developed in the USSR. The dye for the titanium elements may be of any color ranging from silver-white, through various shades of yellow, green and violet, to a red raspberry color. The dyeing is very resistant to atmospheric effects. It has application in aviation, cosmonautics, etc. [Text] [Warsaw SKRZYDLATA POLSKA in Polish No 25, 24 Jun 79 p 21] 2600

USSR

# A STUDY OF THE PROCESS OF ANODIC DISSOLUTION OF TITANIUM UNDER CONDITIONS OF ELECTROCHEMICAL TREATMENT

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 1, 1979 pp 27-28

KUKOV, F. I., KUDIMOV, YU. N. and KRUTIN', A. A., Novocherkassk

[Abstract] Based on the results of spectroanalysis and x-ray structural, thermographic and chemical analysis, and on the analysis of the shape of polarization curves, a mechanism is suggested for the anodic dissolution of titanium under conditions of electrochemical treatment. A growth occurs in the anodic oxide film on the surface of titanium as the potential shifts toward the positive side. At a certain potential value, which depends on the composition and concentration of the solution, thos oxide film breaks down at individual points and the process of anodic dissolution of titanium begins, where $Ti - 3e^- \rightarrow Ti^{3+}$ and $Ti - 4e^- \rightarrow Ti^{4+}$. Insoluble titanium hydroxide, $Ti(OH)_3$, is formed in part by ions of trivalent titanium. Along with this, $Ti^{3+}$ ions are oxidized by protons to $Ti^{4+}$ ions. Orthotitanic acid is formed by ions of tetravalent titanium, which combine with hydroxyl groups, or $Ti^{4+} + 4OH^- \rightarrow H_4TiO_4$. Titanium trihydroxide is also oxidized to orthotitanic acid, under the influence of water, i.e., $2Ti(OH)_3 + H_2O = 2H_4TiO_4$. Under the influence of oxygen, $Ti(OH)_3$ is converted into metatitanic acid, or $2Ti(OH)_3 + 1/2\ O_2 = 2H_2TiO + H_2O$. The value of the ion charge was determined by treating grade VT1-0 commercially pure titanium in a 15-percent solution of NaCl with additions of reactants which produce typical reactions for $Ti^{3+}$ and $Ti^{4+}$ ions. Anodic dissolution of titanium was carried out with a 1-mm electrode gap and an electrode voltage of 18V. An optical device made it possible to observe the change in the color of the solution in the area near the electrodes. The formation of compounds of trivalent titanium was evidenced by a violet and dark green color, respectively, when treating dissolved titanium with an addition of $NH_4CNS$ and $CH_3COONa$. A yellow color evidenced the formation of compounds of tetravalent titanium when dissolved titanium was treated with an addition of $H_2O_2$. Spectroanalysis of dissolution products with a dual-beam Specord-71IR infrared spectrograph showed that there is no OH group in the dissolution products. Microscope investigations and x-ray structural analysis demonstrated that the products of anodic dissolution are amorphous. The data arrived at do not contradict the findings of earlier studies. References 7: all Russian.

USSR UDC: 621.923.021:621.921.34

SURFACE QUALITY OF VT4 TITANIUM ALLOY FOLLOWING DIAMOND POLISHING

Kiev SINTETICHESKIYE ALMAZY in Russian No 4, 1978 pp 51-53

AVERCHENKOV, V. I., FILIN, S. S., ZAYTSEV G. M. and SEMKINA, T. A., Bryansk Institute of Transport Machine Building

[Abstract] The grinding of titanium alloys, with their high ductility and low heat conduction, entails high temperatures in the cutting zone, which results in increasing the chemical activity of the alloy as well as in other undesirable effects. In this connection the possibility of polishing parts of VT4 titanium alloy by means of bars consisting of a steel base bonded to a flexible diamond strip was investigated. Alloy specimens with surfaces having two different roughness parameters $R_{oc}$ = 1.8 and 0.22 μm were polished with the aid of lathe-turret mounted bars oscillating 3 mm and moving at the rate of 1400 back-and-forth strokes per minute upon copious application of a collant consisting of a mixture of kerosens (79%), spindle oil (20%) and oleic acid (1%). The experiments showed that polishing time affects surface roughness the most. Thus after 20 sec of polishing the original roughness of 1.8 and 0.22 μm decreased to 0.13 and 0.064 μm, respectively, whereas after 30 sec the decrease was 0.074 and 0.057 μm, respectively. Thus, polishing by means of flexible diamond strips is an effective technique in the finish machining of titanium-alloy parts. Figures 1.

USSR UDC: 669.017

THE EFFECT OF STRUCTURAL PARAMETERS ON THE LEVEL OF MECHANICAL PROPERTIES OF HIGH-ALLOY VT22 ALLOY

Ordzhonikidze IVUZ. TSVETNAYA METALLURGIYA in Russian No 2, Feb 79 pp 99-104 manuscript received 23 Feb 78

POL'KIN, I. S., SINYAVSKAYA, S. N., NOVIK, F. S. and SHISHKUNOVA, N., Chair of Heat Treatment of Metals, All-Union Correspondence Polytechnic Institute

[Abstract] The relation between mechanical properties and structural parameters of titanium alloys after heat treatment is examined in the case of the VT22 alloy. An experimental study was made using rolled rods of this alloy produced from a single ladle. These rods, 65 mm long and 15 mm in diameter, were variously heat treated, after the residual effects of their original structure had first been eliminated by heating to 950°C. The heat treatment consisted of reheating to various temperature within the ($\alpha+\beta$)-range and holding isothermally at those temperatures for 0.5, 1,

or 5 hrs with subsequent water quenching at the rate of 80°C/sec. The structural parameters measured in this experiment were the volume fraction of the $\alpha$-phase, the specific area of the interphase boundary, the characteristic dispersivity of phases, the distance between $\alpha$-phase particles, and thelength and the thickness of $\alpha$-phase lamellas. The mechanical properties measured in this experiment were the tensile strength, the yield point, the resilience and the Rockwell C hardness. A statistical analysis of the results yields the coefficients of pairwise as well as collective and individual correlation between the respective mechanical properties and structural parameters. Noteworthy is the almost linear dependence of the mechanical strength on the $\alpha$-phase content, with the tensile strength increasing from 82 to 136 kgf/mm$^2$ as the $\alpha$-phase content increases from 11 to 80%. The empirical equations expressing this relation are

$$\text{Tensile strength} \quad \sigma_t = 72.7116 + 0.7240\,\alpha$$

$$\text{0.2 yield point} \quad \sigma_y = 70.6338 + 0.7161\,\alpha$$

The correlation is much waker everywhere else, with a much wider spread of data, so that no linearity can be assumed in any other relation. Figures 3.

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INFLUENCE OF THE ELECTRICAL PARAMETERS OF ELECTROCHEMICAL DIAMOND GRINDING ON THE DURABILITY OF THE VTZ-1 TITANIUM ALLOY

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 2, Mar-Apr 79 pp 22-28

SEDYKIN, F. V., BELOBRAGIN, YU. A., SEGEYEV, N. N., SOTOV, I. N. and NIKIFOROV, A. V., Tula

[Abstract] A study was made to determine the durability of the VTZ-1 titanium alloy in aggressive media, after diamond grinding in an electrolytic bath. Cylindrical specimens 8 mm in diameter were gound with an APP 300 x 127 x 16x5 ASV 160/125 MO 16 100% wheel 0.22 mm deep per double pass, in a 10% $NaNO_3$+ 2% $NaNO_2$ electrolyte. The voltage was varied from 0 to 8 V with either forward (specimen-anode) or reverse (specimen-cathode) polarity. The specimens were then tested in an aqueous solution of 9% $H_2SO_4$ + 2.5% $NH_4CNS$, to ensure uniform hudrogenation of the surface without electrochemical dissolution, at a cathodic current density of 200 A/m$^2$ and under a tensile load of 800 MPa. With the average time till rupture regarded as the durability criterion, electrochemical diamond grinding at a reverse voltage of 408 V or a forward voltage of 3 V resulted in the longest life

of specimens (225 and 180 hours, respectively). A microstructural x-ray and electron microscope examination of hydrogen embrittlement and subsequent fracture revealed cracking in the $\alpha$-phase and residual compressive stresses in a thin crystalline surface layer, depending on the parameters of electrochemical treatment during grinding. This suggests a way to control the quality of VTZ-1 products. Figures 6; References 15: all Russian.

USSR UDC: 539.3.37

HETEROGENEITY OF DEFORMATION FIELDS IN A TITANIUM ALLOYS

Kiev PROBLEMY PROCHNOSTI in Russian No 3, Mar 1979 pp 49-51 manuscript received 15 Feb 78

BOROVIKOV, V. S., VAYNSHTEYN, A. A., SHAGDYR, T. SH., and STRIZHAK, V. A., Pervoural'sk

[Abstract] Equations are derived for calculating the distribution of structural strain and deformation of a titanium alloy. The coefficients of variation of microdeformation occurring in the elastic areas were determined relative to macrodeformation. The relationship of the coefficients of variation for plastic structural deformation to the extent of macrodeformation was established experimentally. The microhardness was measured for the VT1-0 alloy on a 0.01-mm scale for 3 levels of loading. One- an two-dimensional models were constructed describing the distribution of microhardness. The deformation of individual grains increases the average deformation by 3 times or more. The coefficients of variation decrease from 98.6 to 57.5% with increasing macrodeformation. Figures 3; References 12: all Russian.

USSR UDC: 621.791.01:620.192.46

TENDENCY OF SEAMS ON ALUMINUM ALLOYS TO HOT CRACKING DURING FUSION WELDING BY VARIOUS METHODS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 4, Apr 79 pp 35-37 manuscript received 17 Aug 77

ISHCHENKO, A. YA., Candidate of Technical Sciences, Institute of Electric Welding imeni Ye. O. Paton, Academy of Sciences UkrSSR

[Abstract] A comprehensive study was made at the Institute of Electric Welding to determine the feasibility of increasing the resistance of two high-strength aluminum alloys to cracking during welding. Strip specimens, 4 mm thick, of the aluminum-copper- maganese alloys AMg5 and 1201 were tested after welding at the Moscow Higher Technical School. The critical width of the welding seam served as the criterion of cracking resistance; 10-15 specimens were used in each test series. Specimens with narrower than critical seams were subsequently examined for cracks, visually under magnification as well as by x-ray analysis after etching. Four methods of welding were employed, the general trend being a decrease in tendency to cracking with a lower density of concentrated energy during welding. According to the data, the critical seam width is smallest and the cracking resistance highest when electron-beam welding is done at a high rate (60 m/hr). Of the remaining three methods, argon-arc welding with a symmetric alternating current gave the worst results, while argon-arc welding with an asymmetric current containing a large direct component and helium-arc welding with a direct current produced intermediate results. In every case the AMg5 alloy was less prone to cracking than the 1201 alloy. Figures 3; References 7: all Russian.

USSR UDC: 621.791.72:621.373.8

WELDING OF STEEL AND OF TITANIUM ALLOYS WITH HIGH-POWER $CO_2$ LASERS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 4, Apr 79 pp 30-34 manuscript received 14 Apr 78

LEBEDEV, V. K., Academician Academy of Sciences Ukrainian SSR, VELIKO, O. A., Candidate of Technical Sciences, AVRAMCHENKO, P. F., engineer, MOLCHAN, I. V., engineer, YEMEL'YANOV, V. G., engineer, Kiev, KOSYREV, F. K., engineer, SHULAKOV, V. N., candidate of Physico-Mathematical Sciences, FROMM, V. A., engineer, MORYASHCHEV, S. F., Candidate of Technical Sciences, ZUYEV, G. M., engineer, ZINCHENKO, V. M., engineer, Moscow

[Abstract] An experimental study was made of welding with high-power continuous $CO_2$ lasers applied to steel and to titanium alloys. Specimens 3-6 mm

thick were welded with an LT-1 laser generating up to 5 kW beam power, special nozzles also being used here for injection of helium or a helium-argon mixture. In the first case the laser beam was focused by means of a KCl lens; in the second case the laser beam was focused by means of metallic Cassegrain reflectors, a spot of 0.3-0.8 mm in diameter being thus attainable with a convergence angle of 8-10° and capable of a 6-mm-deep penetration. At a constant welding rate the height of the seam was found to increase almost linearly with the laser power. With higher welding rates at a constant laser power, on the other hand, both the height and the width of the seam were found to decrease to some threshold. The seam formation was, furthermore, found to depend strongly on the displacement of the smallest spot diameter from the specimen surface. Carbon steel St3sp was welded at rates of 150-15 m/hr (3--6-mm-thick specimens respectively) in a protective helium-argon shielded. Low-alloy steel 17GS (0.14% C, 1.2% Mn, 0.34% Si, 0.16% Cr, 0.08%Ni, 0.0%4% V) was welded at rates of 150-230 m/hr (10-mm-thick specimens) or 100-65 m/hr (15- and 20-mm-thick specimens, respectively). The titanium alloy was welded at rates of 160-95 m/hr (4-20-mm thick specimens, respectively) in a protective helium-argon shield. All joints were subsequently tested for tensile strength, toughness, microhardness, phase composition and nonmetallic inclusions. The results indicate that laser welding of these materials within the given range of thickness at relatively high rates is feasible. Figures 7; References 3: all Russian.

USSR UDC: 621.791.01:539.378.3:669.295

DIFFUSION WELDING WITH FORCED DEFORMATION OF THE VT6 TITANIUM ALLOY

Kiev AVTOMATICHESKAYA SVARKA in Russian No 4, Apr 79 pp 25-27 manuscript received 26 May 78

KARAKOZOV, E. S., Doctor of Technical Sciences, TERNOVSKIY, A. P., Candidate of Technical Sciences, TARLAVSKIY, V. E., engineer, Moscow Evening Institute of Metallurgy

[Abstract] Forced deformation is an effective method of improving the diffusion welding process, with the strain rate becoming the controllable technological variable and the load related to the resistance of the material at a given temperature becoming a dependent variable. An experimental study of this process was made, applicable to the VT6 titanium alloy (Ti+ 6.63% Al + 4.6% V). Rod specimens containing a large amount of $\alpha$-phase and a small smount of $\beta$-phase, with a distinct grain orientation, were tested in welding with deformation. Depending on the strain rate and on the temperature, the welding time could be varied from 240 to 10 sec. Best results, namely an equiaxial fine-grain structure in the joint zone, were attained at T= 960°C. At this temperature a strain rate of approximately

$8 \cdot 10^{-4}$ $sec^{-1}$ yielded the highest toughness and the highest degree of superplasticity, with the welding time reducible to 56 sec. Approaching the polymorphous transformation temperature, close to 1030°C, tended to increase the grain size and to produce pores within a comparatively short welding time. According to these data, obtained with an Instron-1193 testing machine, diffusion welding with the thus better controllable mechanism of plastic deformation provides the basics for development of a new high-yield technology in the area of precision welding. Figures 4; References 15: 12 Russian, 3 Western.

USSR UDC: 621.791.052:539.378.3:669.782+669.71

MECHANICAL PROPERTIES OF WELD JOINTS OF SINGLE-CRYSTAL SILICON WITH ALUMINUM PRODUCED BY DIFFUSION WELDING IN HYDROGEN

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 79 pp 31-32

ROMANOVSKIY, V. F. and VINITSKIY, M. YA, Engineers

[Abstract] The optimum parameters of diffusion welding in hydrogen were determined for the case of single-crystal semiconducting silicon and aluminum. It was established that by giving the weld joint an adequately long isothermal soak during welding (up to 60 minutes), it was possible to produce almost equal-strength joints for both a polished and ground silicon surface whereupon welding mode, surface treatment quality and nature of alloying the near-surface layers with silicon exert an effect. The best parameters for producing mechanically strong contact weld joints over a large area are to perform diffusion welding at 500-550°C and at a pressure below the critical slip stress in silicon (1.0-2.0 $kgf/mm^2$). Figures 3; References 4: all Russian.

USSR UDC: 621.791.052:621.9.048.6

ULTRASONIC TREATMENT OF WELD JOINTS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 5, May 79 pp 32-33

KRIVKO, V. P., Engineer, and PROKOPENKO, G. I., Candidate of Physico-Mathematical Sciences

[Abstract] A study was made of the action of ultrasonic vibrations on the

strength of weld joints and on the redistribution of residual macrostresses. Aluminum alloys 1915, VAD1, and AMg6 were welded from sheet 6-8 mm thick and the 20-mm-wide heat-affected zone was treated with ultrasonic waves using oscillation amplitudes amounting to 20 microns. The multisides ultrasonic tool used is described which lowered the tensile stresses in the weld joints by 80-100%. The yield point of these aluminum alloys was increased by approximately 30% while long-time strength rose insignificantly. Figures 2; References 4: all Russian.

USSR

ELECTROSPARK ALLOYING WITH T15K10 AND VK8 HARD ALLOYS FOR THE PURPOSE OF INCREASING WEAR RESISTANCE

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian, No 2, Mar-Apr 79 pp 37-39

PLESKACH, V. M. and AVERCHENKO, P. A., Zaporozh'ye

[Abstract] Increasing the wear resistance of friction pairs is a major problem being investigated by the Chair of Metal Technology at the Zaporozh'ye Institute of Machine Design imeni V. Ya. Chubarov. Cast SCh21-40 gray iron, ZhChSSh high-strength iron, and cast 12Kh13 steel friction pairs were studied. These materials were surface-alloyed with VK8 and T15K10 alloys by the electric-spark method in an EFI-46A apparatus. The electrodes made of these alloys were vibrated at a frequency of 50 Hz and with an amplitude of 0.30-0.35 mm, at a nominal current of 1.2-1.5 A. Wear tests were then performed in special fixtures made of St 45 steel, with the mating surfaces sliding at a velocity of 5.5 m/s without lubrication under a pressure of 5 kgf/cm$^2$ across a contact area of 2 cm$^2$. The wear was measured by the loss-of-mass method with a BLA-200M analytical scale. The results of a series of 2-minute rubbing tests indicate that the average rate of wear of such alloyed surface layers was ten times lower than that of the base materials. This is attributed to the hardness of T15K10 and VK8, the former alloy yielding a slightly higher wear resistance. Inasmuch as the electric-spark process is associated with the formation of oxide and nitride films, however, inevitably the bonding of individual particles of the softer material will spotwise be inadequate for ensuring such a high wear resistance. Figures 2; References 11: all Russian.

USSR UDC: 620.181:669.24'294

STRUCTURAL FEATURES OF NICKEL ALLOYS ALLOYED WITH TANTALUM

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 79 pp 19-22

BUROVA, N. N. and MASLENKOV, S. B., Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin

[Abstract] A comparative analysis was made of the structure and properties of two alloy types: A--EI857 with a total Al and Ti content of 9% and B--TRW VIA alloyed with tantalum. The alloys were produced by directed crystallization and had a characteristic oriented structure. The long-time strength of alloy B, with an optimum Ta content of 9%, significantly exceeded that of Alloy A in the 1000-1100°C interval. Investigation of the

type B alloy showed that there was a direct relationship between Ta concentration and high-temperature strength. The increased heat resistance of Ni-Al alloys, when alloyed with Ta, can be mainly associated with the increased volume fraction of gamma'-phase and with changes in phase composition. Micro-x-ray spectral analysis showed that the gamma'-phase in the type B alloy contains more refractory elements--Mo, W and Ta. If part of the Al in the gamma'-phase of alloy A is replaced by Ti then in alloy B the Al is partially replaced by the more refractory Ta whose content in the strengthening phase reaches 11%. Whereas in alloy A the formation of chromium carbides lowers ductility, in alloy B, with a lower chromium content, the probability of $Cr_{23}C_6$ forming is decreased and the secondary carbides in alloy B contain 60% Ta. These secondary carbides contain less Ti, Nb, W and Mo but increased Zr and Hf, which prevent formation of chromium carbides. Figures 1; References 3: 1 Russian, 2 Western.

USSR UDC: 620.181:669.24

PHASE COMPOSITION OF HIGH-TEMPERATURE ALLOY EO539

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian May 79, pp 22-25

PIGROVA, G. D., Central Scientific Research and Planning Design Boiler Pipe Institute imeni I. I. Polzunov, Leningrad

[Abstract] A study was made of the change in phase composition of six melts of a basic EP539 alloy during extended aging at 650-900°C. The nominal composition of this alloy is (in %): 3-4 Al, 2-3 Ti, 17-19 Cr, 5-7 Mo, 2.5-4 W, 0.04-0.09 C and less than 0.5 Si. Samples from the six heats were heat treated to form the gamma'-phase and then aged for intervals ranging from 1000 to 10,000 hours. It was noted that the phase composition of both heat treated and aged samples was not the same after treatment. Only carbide and boride phases were observed in each heat after heat treatment but after aging at 750-900° the phase transformations were different. In heats 1 and 2 there were only carbide reactions. In 3 and 4 intermetallide $\sigma$ and $\mu$-phases in equal quantities were detected. In 5 and 6 the $\sigma$- and $\mu$-phases were formed with primary precipitation of the $\sigma$-phase. The varying nature of secondary phase formation can be explained by the varying content of Al and Ti in the heats, i.e., a different amount of gamma'-phase formation from the aging process. The amount of gamma'-phase increases with increased Al and Ti content, which causes a high concentration of Cr, Mo and W in the gamma'-phase and, consequently, leads to the formation of topologically close-packed phases. The amount of $\sigma$- and $\mu$-phases is a direct function of the concentration of Al and Ti. References 4: 3 Russian, 1 Western.

USSR UDC: 669.14.018.44:620.172.251.2

CAUSES OF LOWERED RESISTANCE OF SHORT-TIME CREEP IN ALLOY KhN67VMTYu AT 700°C

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 79 pp 25-26

BANNYKH, O. A., DORONIN, I. V., MAKARENKO, V. I., GOLIKOV, V. A. and TSUKROV, Ye. A.

[Abstract] The loss of strength due to short-time creep is discussed as it applied to KhN67VMTYu at 700°C. In a fifteen-minute test at the designated temperature and under a load of 52 kgf/mm$^2$ an anomalously large total relative elongation was noted which achieved a value of 1.5-3.5%. This anomaly was believed to be caused by disordering of the solid solution at the initial moment of plastic deformation. Ordering in the Ni-Cr solid solution is controlled by diffusion of matrix atoms. The intensity of diffusion development can be determined mainly by the test temperature where the breakdown of close ordering depends on the rate of tension. During short-time tensile tests of this alloy, well defined serration was noted on the stress diagram in the 300-500°C interval. At 500-600°C rare drops in stress (jumps) are only noted in the instant of sample necking when, as a result, the localization of the deformation site causes the deformation rate to increase sharply. This phenomenon was also noted for other Ni-Cr base alloys EI435, EI437A, EI437B, EI437BU, EI617, EI598 as well as alloys EI867 and EP109. Figures 1; References 5: all Russian.

USSR UDC: 669.14.018.44:539.214

HIGH-TEMPERATURE DUCTILITY OF HEAT-RESISTANT Cr-Ni ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 79 pp 27-30

GULYAYEV, A. P., BULAVINA, L. S., CHERNYAK, G. S., Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin and the Elektrostal' Plant

[Abstract] High-temperature Ni-base alloys were investigated where the degree of alloying varied from two- (Ni-Cr) to six-component (Ni-Cr-Mo-Nb-Al-Ti) alloys. Alloys of the Ni-Cr and Ni-Cr-Mo systems are not good aging alloys whereas the remaining alloys are ageable to a higher degree than complexly alloyed materials. There is a smooth increase in ductility with rise in temperature for unageable two- and three-component alloys. The ductility maximum for aging multicomponent alloys typically lies at

200-250° below the melting point and rules out the explanation of ductility loss as fusion of grain boundaries at high temperatures. Nor does the presence of contaminants satisfactorily explain this loss since these alloys have a very low impurity content. From mechanical tests and metallographic studies it was shown that the temperature of dissolution of the carbide phase and segregation of carbon along grain boundaries starts the lowering of ductility in highly alloyed alloys. The greater the degree of alloying the more intense the grain growth in the solid solution. The decrease of the total intergranular boundary, which results in increased carbon concentration in the near-boundary zones, intensifies alloy embrittlement at high temperatures. Figures 3.

USSR UDC: 669.14.018.44:620.186.5

EFFECT OF VARIOUS FACTORS ON THE RECOVERY AND RECRYSTALLIZATION OF A NICKEL-BASE HEAT-RESISTANT ALLOY

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 79 pp 33-37

LEVIN, YE. YE. and TIKHONOV, V. I.

[Abstract] KhN65VMTYu (EI893) alloy was investigated to study the effect of various factors on its recovery and recrystallization. Chemical composition of this alloy was (in %): $\leq$ 0.08 C, $\leq$ 0.5 Si, $\leq$ 0.5 Mn, 15.0-17.0 Cr, 8.0-10-0 W 4.0-5.0 Mo, 1.2-1.6 Ti, 1.2-1.6 Al, 0.010 B and 0.025 Ce. The specifics studied were effect of cold working on intragranular structure during recovery and recrystallization, effect of cold working on recrystallization, effect of dispersed phases on selective recrystallization and effect of hot deformation conditions on macrogranularity. The disappearance of an excess concentration of points defects in this alloy starts upon heating to 100°C and is completed around 250°C. A noted change in the polygonal structure can be observed at 750-850°C. Improvement of the intragranular structure can be extended into the process of selective recrystallization up to almost 1160-1180°C. Primary recrystallization starts at 900-950°C and ends at 980-1020°C in relation to the degree of prior cold working. The temperature relationship of the selective recrystallization process is determined to a significant degree by the temperature of the dispersed phase dissolution. The rate of selective recrystallization varies in time by a parabolic law. A decrease in temperature and degree of hot deformation increases somewhat the metal's tendency to selective recrystallization. The optimum mode of recrystallization annealing is 1180°C for 2-3 hours for the alloy in an open-arc curnace and 1160°C for 2-3 hours in open induction melting. Non-uniform distribution of the dispersed phases has a basic influence on the microgranularity of the alloy. Micro-x-ray spectral analysis was performed jointly with A. I. RYBNIKOV. Figures 5; References 8: 6 Russian, 1 Western, 1 Unknown.

USSR UDC: 669.018.44:548.53

RECRYSTALLIZATION OF KhN70MVYu ALLOY

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 5, May 79 pp 37-39

RYABOV, V. I. and VOYTSEKHOVSKIY, V. A.

[Abstract] Recrystallization processes were studied to determine the heat treating modes for wire made of KhN70MVYu alloy. The study was made using 14-mm-diameter hot-rolled rods and cold-deformed wire with reductions of 10, 20, 30, 40 and 50%. Samples were quenched from 900-1250°C with the wire having been soaked at the indicated temperatures for periods of 20, 40, 60 and 120 minutes prior to quenching. Hardness, microhardness and mechanical properties were used to determine optimum quench temperatures using microstructural and x-ray analysis methods. Too much reduction lowers the recrystallization temperature from 11 to 1000-1050°C. This was evident when the hardness dropped significantly after heating to 900°C and soaking for the indicated times after 10-50% reductions. At 1200°C and higher there is extensive grain growth. Only at reductions less than 10% and quenching from 1100°C is grain refinement observed and it was determined that 1150°C was the optimum temperature for producing the desired properties as long as reduction is less than 10%. Figures 4.

USSR UDC: 669.293-982

INFLUENCE OF THE COMPOSITION OF RESIDUAL VACUUM GASES ON THE HEAT RESISTANCE OF ALLOY Nb-Zr-C

L'vov FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 15 No 2, 1979 pp 62-65 manuscript received 6 Mar 78

MAKSIMOVICH, G. G., LYUTYY, YE. M., YELISEYEVA, O. I., KISSIL', A. YE. and SINCHENKO, N. M., Physiomechanical Institute, Academy of Sciences UkrSSR, L'vov

[Abstract] Refractory metals and alloys for use at high temperatures and low pressure have high reactivity with respect to the residual gases of the inert environment in which they are usually tested. A study is made of the influence of the residual gases of the vacuum achieved by various methods of evacuation, on the mechanical properties and structure of the niobium alloy Nb - 1% Zr - 1% C. An oil vacuum is produced by means of an oil-vapor diffusion pump, and an oil-free vacuum is achieved by means of magnetic discharge diode pumps. A radio frequency mass spectrometer is used to monitor the composition of the residual atmosphere, whereby

it is revealed that the major difference in the composition of residual gas components consists in the percentage of radicals of heavy $C_nH_n$ hydrocarbons and of gases of oxidants. Long-term aging in a vacuum produced by the oil-free method of evacuation results in increases resistance at room temperature in specimens of an Nb-Zr-C alloy as compared with that of specimens aged in an oil vacuum. On the other hand, in high-temperature testing at 900 and 1000°C, the strength and resistance to creep becomes greater in specimens which have been aged in an oil vacuum. The apparently contradictory results are explained by the fact that the process of interaction between oxygen and niobium and its alloys at high temperatures and low pressure is divided into several stages. At the initial stage oxygen is absorbed linearly, and all the absorbed oxygen goes into solid solution to the point of total saturation of the niobium. With a change in temperature or pressure or with the passing of time, the linear stage of oxidation can be replaced by a parabolic one, caused by the formation of NbO and then $NbO_2$, whereby the controlling mechanism is the diffusion of oxygen in the niobium lattice. At the final stage, which is linear, porous $Nb_2O_5$ forms, which does not protect the niobium from further oxidation. The combined result of the effect of high temperatures and an oxygen-containing environment is the appearance on the surface of specimens of $Nb_2O_5$, resulting in a decline in the resistance to creep of specimens aged in an oil-free vacuum, as compared to those aged in an oil vacuum. Tests for strength at 1000°C and creep at 900°C show that the strengthening effect of carbon is greater when this alloy is used at high temperatures than is the strengthening effect of oxygen. Figures 3; References 6: 5 Russian, 1 Western.

USSR UDC: 669.017.539.4:620.178.7

MAXIMUM DYNAMIC STRENGTH OF STEEL AND A METHOD FOR DETERMINING IT

L'vov FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 15 No 2, 1979 pp 28-31 manuscript received 6 Oct 78

KAL'NER, D. A. and BASIN, F. I., Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin, Moscow

[Abstract] A method is described for determining the maximum dynamic strength of steel, a new characteristic of steel which depends simultaneously on the strength of the material and on its capacity for plastic deformation at a specific temperature. The procedure for determining this characteristic is rather simple, employing a high-speed pneumatic impact machine. A steel wire is subjected to transverse impact on the machine, whereby uniaxial loading takes place at the rate of elastic straining, along with a single unloading wave. During failure, the maximum dynamic strength and the

maximum plastic deformation are observed near the point of impact. If the initial cross sectional area, $F_0$, of the wire is known, it is possible to determine the force, $P_{max}$, developed under the striker and the maximum dynamic strength, $\sigma_{b\ dm}$, at any section of the wire sample where there is no residual plastic deformation, or $\sigma_{b\ dm} = P_{max}/F_0 = \sigma_{max}(1 - \varepsilon_{max})F_0/F_0 = \sigma_{max}(1 - \varepsilon_{max})$. Essentially, from the physical standpoint, $\sigma_{b\ dm}$ is the initial elastic stress sustained by the material under ultra-high-speed loading. It has been found that the greater $\sigma_{b\ dm}$, the greater $v_{kr}$, the mimimum value of the rate of transverse impact with which failure takes place beneath the striker, and, furthermore, $v_{kr}$ is proportional to the square root of $\sigma_{b\ dm}$, or $v_{kr} = C_v^m\sqrt{\sigma_{b\ dm}}$, where $C_v^m$ is the dynamic coefficient. The value of $C_v^m$ has been shown to be constant for a wide range of steels. When samples have equal dimensions and the rates of transverse impace are identical, the elastic deformation and elastic stresses are also equal; but for each material the stresses reach $\sigma_{b\ dm}$, or failure, at a specific rate, $v_{kr}$. Therefore, knowing $v_{kr}$ and assuming $C_v^m = 12.5$, a simplified method is possible for determining $\sigma_{b\ dm}$. In the method suggested, a two-strand loop 10 to 15 mm long is fastened to one of the ends of the wire at the sensing end. This loop has predetermined dynamic properties which are greater than the rest of the sample. In spite of the different cricital rate of transverse impact for this compound sample and a simple steel wire (a function of the loading diagram), $\sigma_{b\ dm}$ is shown to be practically the same in both cases. The prime advantage of using compound samples of this type is the ability to make reliable tests at reduced temperatures with a guaranteed temperature for the entire sample tested. The results are given of tests on a turned steel ring, utilizing the principles discussed. The testing of compound samples is considered a universal method for determining $\sigma_{b\ dm}$ in different materials in different states. Figures 1; References 4: all Russian.

USSR UDC: 539.4

KINETICS OF BRITTLE FAILURE OF SOLIDS AND THE POSSIBILITY OF PREDICTING IT FOR STATIC AND CYCLIC LOADING

L'vov FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 15 No 2, 1979 pp 20-26 manuscript received 8 Aug 78

STEPANOV, V. A., SHPEYZMAN, V. V. and ZHOGA, L. V., Physical-Technical Institute imeni A. F. Ioffe, Academy of Sciences, USSR Leningrad

[Abstract] On the basis of a great deal of experimental data collected hitherto, the problem of brittle failure is approached from the viewpoint of kinetics, i.e., as a process taking place in time. The distinctive features of brittle failure are related to the simultaneous process of

microplastic deformation, which results in the slow relaxation of local stress concentrations. This approach is shown to make possible, with greater physical substantiation, the prediction of the probability of sudden failure. The need for such a prediction has become acute because of the fact that new high-strength, low-plasticity materials exhibit delayed failure, i. e., failure occurs a long time after an apparently safe dead load is applied. Several examples are given of estimating the probability of sudden failure to cases of static and cyclic loading, and the results of experimental verification are presented. A diagrammatic representation is given of the dependence of durability on stress for a brittle material under static loading, and the same relationship is shown for monocrystalline and polycrystalline zinc. The theoretical discussion originates from the equation for durability, $\tau$, for the case when a dead load is applied and as the result of rapid relaxation a stable level of local stresses, $\sigma_\ell$, is established, typical of plastic failure: $\tau = \tau_0 \exp [U_0 - \gamma\sigma)/kT]$, where k is the Boltzmann constant, $\tau_0 = 10^{-13}$ s, $U_0$ is the activation energy for theprocess of failure, product $\gamma\sigma = V\sigma_\ell$, where V is the activation volume, $\sigma_\ell = n\sigma$, where n is the stress concentration factor and is the mean stress, and T is the temperature. Relaxation processes take place slowly with low-temperature brittle failure, and the value of $\gamma$ in this equation does not remain constant with $\sigma$ = const. An equation is presented for durability when it is shorter than the time for establishment of a steady-state level of local stresses. The equations presented are confirmed by experimental data on sinz from static tensile testing. Predictions are made regarding the time prior to failure with different values of under static loading on the basis of the analysis of brittle failure made here. A similar discussion is presented for the case of cyclic loading. Figures 5; References 18: 17 Russian, 1 Western.

USSR UDC: 520.17

ON THE EFFECTIVENESS OF UTILIZING SURFACE PLASTIC DEFORMATION FOR PREVENTING DEVELOPMENT OF CRACKS IN CYCLIC LOADING

L'vov FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 15 No 2, 1979 pp 15-20 manuscript received 22 Feb 78

ROMANIV, O. N., SIMIN'KOVICH, V. N. and STEPANOV, V. G., Physicomechanical Institute, Academy of Sciences, UkrSSR, L'vov

[Abstract] A study was made of the influence of surface plastic deformation by different methods on the behavior of fine cracks in structural materials under cyclic loading. The study utilized parameters of linear fracture mechanics for the purpose of gaining information on the effectiveness of employing surface strain hardening for retarding the development

of fatigue cracks. The specimens used were cut from a hot-rolled sheet of aluminum alloy AMG-61, containing 5.5 to 6.5 percent Mg and 0.8 to 1.1 percent Mn, as supplied commercially. A smooth rectangular specimen measuring 6 x 15 mm in cross section was used, with a surface flaw in the form of a crack 0.5 mm deep. The surface containing the crack was hardened, using a special device making it possible to eliminate alteration of the cross section's geometry and to ensure evenness of straining over the breadth of the specimen. Hardening was performed by three methods: peening with cast steel shot, using an AD-1 unit; low-rate pneumatic impact hardening, using an MP-2 hammer; and rapid-rate hammering, using an ultrasonic hammer. Hardened specimens were subjected to cyclic cantilever bending. The experimental data were computer processed. Kinetic fatigue curves were plo-ted, illustrating the dependence of the rate of crack growth on the loading cycle. Specimens ere tested both in air and in a three-percent solution of NaCl in water. Curves were also plotted, illustrating the dependence of the change in the rate of crack growth on the depth of the crack. The brst characteristics for resistance to crack growth under cyclic loading were exhibited by specimens hardened ultrasonically. This was explained by the fact that permanent stresses in them, of very high magnitude, lay at the deepest levels. The presence of a corrosive environment (the NaCl solution) intensified fatigue crack growth in aluminum alloy AMG-61. It was concluded that surface plastic deformation is an effective method extending the life of products by retarding the development of cracklike flaws in the material or by restraining them completely. The effectiveness of employing surface plastic deformation for retarding the development of cracks under cyclic loading increases when products function in a corrosive environment. The degree to which the crack resistance properties of products are improved after employing this method depends on the level of residual compressive stresses and their maximum depth and arrangement. An optimal ratio of the maximum level and depth of residual stresses is achieved in the surface layer of a material when the ultrasonic method is employed. For each product and each set of strain hardening conditions there exist critical crack depths at which the sensitivity of the rate of crack growth to surface hardening disappears. The hardened layer has a specific field of influence, and an analytical description of the behavior of a crack in a product which has been hardened by this method is possible. Figures 5; References 7: 6 Russian, 1 Western.

USSR

INVESTIGATIONS OF THE STRUCTURE OF COMPOSITE METAL-POLYMER FILMS BASED ON ELECTROLYTIC IRON

Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 1, 1979 pp 31-35
TERKHUNOV, A. G., Kirovograd

[Abstract] The results are presented of studies which demonstrate that

the structure and texture of electrolytic iron change when highly dispersed powders of plastics are added to the electrolyte, and that it is possible to control the formation of the properties of metal-polymer films in the process of their electrodeposition. Specimens were obtained by using an iron plating electrolyte consisting of 600 g/l of ferric chloride and hydrochloric acid with a pH or 0.8 to 1.0. Powders of polyamide and polyvinylchloride were used as phase-two particles. The concentration of polymer particles in the electrolyte varied from 5 to 30 g/l. In the deposition process, the electrolyte was stirred at the rate of 20.8 rad/sec and electrodeposition took place with a current density of 30 A/dm$^2$ and a solution temperature of 40°C. A UKhP-5A electronic microprobe was used to make a quantitative analysis of the composition of the metal-polymers and of the evenness of the distribution of polymer particles in the film. The use of polyvinylchloride was dictated by the fact that it contains chlorine, which can be excited by a concentrated electron beam and emit characteristic x-rays. A topographic photograph was obtained from beams of reflected electrons, and this photograph was used to assess the evenness of the distribution of polymer particles in the film. A JSM-S1 scanning electron microscope was used to study structural changes in galvanic iron when polymeric additions are added to it. The texture of the electrolytic deposits was evaluated by means of an inverse pole figure. The microphotographs produced provide information on the distribution of polymer inclusions over the volume of a specimen of the metal matrix, on their dimensions, shape, number and external structure, and on the structure of galvanic iron and on its modification under the influence of additions. The data produced confirm the dispersion of a galvanic iron deposit under the effect of highly dispersed powders of plastics and the transformation of its structure from macrocrystalline to microcrystalline, with the dominating orientation of crystals in the plane parallel to current lines. Foreign particles play the role of distinctive centers of crystallization. The presence of a clearly pronounced texture in metal-polymer films gives evidence of a fiarly sharp difference in the rates of growth of crystal boundaries in the presence of foreign particles in the electrolyte. Figures 3; References 5: all Russian.

USSR

ON THE FORMATION OF THE SIDE SURFACE OF SMALL-DIAMETER RECESSES IN ELECTROCHEMICAL MACHINING

Kishinev ELEKTRONNAYA OBRABOTAK MATERIALOV in Russian No 1, 1979 pp 24-26
ZAYTSEV, A. N., POLYANIN, V. I., ZHURAVSKIY, A. K. and GEPSHTEYN, V. S., Ufa

[Abstract] The electrochemical machining process for forming recesses has a considerable influence on formation of the side surface of the recess, in that this process is accompanied by the origin and collapse

of gas-vapor bubbles, which in the case of small recesses are as large as the gap between electrodes. A procedure is described for measuring the rate of growth and volume of the gas-vapor bubble and the duration of the electrochemical effect on the side surface. The duration and nature of the electrochemical effect on the side surface are determined with reference to moments of interruption in and to the amplitude of the electrochemical current between the cathode and different points on the side surface of the recess as the bubble evolves in it. This procedure has been tested with an experimental setup, in which the negative electrode, in the form of a polished tungsten rod with a flat end, was placed in a recess filled with a 5-percent $NaNO_3$ solution, the side walls and bottom of the recess representing a divided anode separated by dielectric spacers. In breakdown between the end of the electrode and the bottom section of the anode a discharge channel forms, surrounded by a gas-vapor bubble, which forces the electrolyte out of the interelectrode gap when the bubble expands. A dual-beam oscilloscope is used to record interruptions in current and its magnitude. A special square-wave generator is used for supplying a voltage pulse to the interelectrode gap. The duration of the electrochemical effect on the side surface of the recess is a function of the time the gap is filled with the gas-vapor bubble and the height to which the bubble rises. The amplitude of the electrolysis current is a function of the breakdown voltage during the lag and of the arcing voltage after breakdown. Depending on conditions, the gas-vapor bubble either leaves the recess or just reaches some critical height. If the critical height is exceeded in the latter case, the duration of the electrochemical effect is ready and equal to the duration of the voltage pulse applied. From on the data produced, it is concluded that specific treatment conditions must be selected on the basis of mutually contradictory stipulations. On one hand, conditions must be selected whereby the gas-vapor bubble is able to leave the recess during the time the pulse is at work. This is necessary to ensure sufficiently complete removal of erosion products from the gap and a more even distribution of the intensity of the electrochemical effect over the length of the generatrix. On the other hand, the volume and rate of growth of the bubble must be such that a side space is created which is sufficient to remove the erosion products and the imperfection layer formed at the erosion stage. Figures 4; References 3: all Russian.

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INFLUENCE OF THE COMPOSITION OF THE $\gamma'$ PHASE ON THE PROPERTIES AND STRUCTURE OF HEAT-RESISTANT DISPERSION-HARDENING NICKEL ALLOYS

IAN SSSR, METALLY in Russian No 3 May/Jun pp 139-146, manuscript received 3 Aug 77

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[Abstract] The composition of the $\gamma'$ phase of nickel alloy was altered by replacing an equiatomic quantity of one of the variable $\gamma'$-forming elements (Al, Ti, Nb) with another. The base for the model alloys was 80% Ni + 20% Cr, to which the $\gamma'$-forming elements were added. Three series of alloys were produced in a type ISLV vacuum induction furnace at an argon pressure of 150 mm Hg. It was found that an increase in the Ti/Al or Nb/Al ratio resulted in an increase in strength and a decrease in ductility, and an increase in thermal stability. An increase in the Nb/Al ratio caused an increase in the rate of formation of the $\gamma'$ phase and a decrease in the content of the $\gamma'$-forming elements in this phase. With otherwise equivalent conditions, an increase in the content of the $\gamma'$ phase causes an increase in short-term strength and a decrease in ductility. Niobium has a greater positive influence on the mechanical properties of nickel alloys than does titanium. Figures 5; References 8: 5 Russian, 3 Western.

USSR UDC: 669.112.227.346

STUDY OF AGEING OF MARTENSITE IN THE ALLOYS Fe-Ni-Ta AND Fe-Ni-Co-Ta

IAN SSSR, METALLY in Russian No 3, May/Jun 77, pp 131-138, manuscript received 23 Jan 78

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[Abstract] Two groups of alloys were studied: three-component Fe-Ni-Ta alloys with varying content of Ta and four-component Fe-Ni-Co-Ta alloys with varying content of cobalt. The alloys were made in a vacuum induction furnace with technically pure materials. In order to study the process of ageing of the martensite, the changes in hardness and resistivity were determined after heating to various temperatures. The quantity of residual gamma phase was determined after the heating by an X-ray method. Hardening was observed after heating to temperatures above 25-200°C. Heating to 500°C produced the maximum hardening. The experiments indicated that hardening occurred primarily in the stage preceding formation of Ta-based intermetallic segregations. Introduction of Co leads to additional hardening upon ageing. The ageing process occurs in two stages. At relatively low temperatures, zones (segregations) are formed; at higher temperatures, above 500°C or so, dispersed intermetallide particles are formed. Figures 4; References 17: 13 Russian, 4 Western.

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